Point-by-point response to the reviews

RC1: 'Comment on egusphere-2024-513', Anonymous Referee #1, 03 Apr 2024

Dear Author

I reviewed your paper "Local floods in Madeira Island between 2009 and 2021. Rainfall analysis and risk assessment in mountain streams". Despite I recognize that you and your co-authors worked a lot on it, and your English is perfectly understandable, I think that your paper is still not ready for an international journal as NHESS. In the following, I will describe the points that not convinced me and I give you some suggestions to strength them.

First of all, the paper is shaped as a case study, a report of events occurred in a specific site, without any possible relation with other case studies/sites. I suggest to ask yourself what a reader (that is not interested to your study area) could learn from your paper. The methodology? In this case you should strength the methodology description, introducing a flow chart and keeping in mind people that are interested in reproduce the same approach. You should give less emphasis to the description of the effects of the events, which are local, and repeat themselves everywhere, even with stronger severity.

Answer: The flowchart has been drawn up and correspond to Fig. 1 in the new version of the manuscript. I believe that in the new version of the methodology we can find more detailed information on the steps that are followed to obtain critical rainfall threshold values, and, in order to better understand how the temporal variation of rainfall can influence the occurrence of torrential flood events.

It is difficult to appreciate the actual significance of this research because methodology and results are merged and it is difficult to understand what are the premises and what are the results. More in general, you should work to highlight:

what is the aim of the paper?

Answer: The primary objective of this study is to determine critical precipitation threshold values that can lead to torrential flows.

What you are doing in this paper?

Answer: To achieve this goal, we will base our analysis on historical torrential flow events and past rainfall measurements. Specifically, we will compare data from rainfall events that triggered torrential events with data from those that did not.

And why?

Answer: It is worth noting that this study was only feasible due to the availability of high-quality base data. The data includes excellent temporal resolution readings at 10-minute intervals from a network of approximately 40 rain gauges distributed across different locations. These devices provide comprehensive spatial coverage for rainfall monitoring in the catchments of Madeira Island.

What is the need that this paper is going to meet?

Answer: This article aims to address an existing gap related to critical thresholds for heavy rain and subsequent torrential flows. In our opinion, this study will significantly reduce uncertainty concerning precipitation thresholds on Madeira Island.

In what way this will happen?

Answer: This new data can be used for establishing accurate rainfall thresholds for torrential flow early warning systems.

Answering to these questions could help you to rearrange the paper in a way more similar to the classical structure of scientific papers.

Particularly, Introduction must state the objectives of the work and provide an **adequate background, placing the study in a broad context and highlight why it is important**. It should define the purpose of the work and its significance and the current state of the research field reviewed using key (and recent) publications, also

highlighting controversial and diverging hypotheses. Oppositely, your Introduction is an introduction to the study area and no recent papers with a similar approach are quoted and compared in terms of objectives and methodology to your paper

Answer: The introduction to the article has been revised in line with your recommendations. The main objective of the article is to apply a specific methodology to derive precise information regarding critical rainfall thresholds that may lead to torrential floods. In practice, this involves identifying the critical combination between the rainfall during the event and the accumulated rainfall from preceding days and weeks. This information serves as a crucial input variable for a flood early warning system.

Methodology must provide sufficient details to allow the work to be reproduced by an independent researcher

Answer: The methodology was also reviewed, and a flowchart was created to assist any researcher in reproducing it.

Conclusions must report the conclusions (not the synthesis) obtained from your study and possible applications in other frameworks, highlighting whether some of them have generic application, rather than being case-specific.

Answer: This topic was also revised accordingly.

About figures: you should do a selection of most significant figures for readers customized to see geomorphic effects of floods and landslides. Captions of figures and tables are very long: I suggest to review them.

Answer: I appreciate the suggestion to select the most significant figures, because in fact we can better visualise the effects of floods through one or two examples.

Tables should be formatted in a better way, avoiding redundancies and rows with more than a line (you should simply enlarge the columns…). And moreover, in an international journal you should try to summarize instead of present long lists of data. Actually, you should identify and propose only data functional to highlight something (i.e. review tab 4).

Answer: The text of the figure and table legends has been simplified as much as possible, and the formatting of the tables has also been revised. In the context of modifying the article's structure, it was decided to delete Table 4.

References denotes the absence of a specific research on recent similar papers. I suggest to do this step before rearrange the paper and to add to references only the articles quoted in the paper (Blöschl is only in references)
I hope that these suggestions can help you to improve your paper.

Answer: The work of researching and updating the bibliographical references was carried out as part of this revision of the manuscript.

RC2: 'Comment on egusphere-2024-513', Anonymous Referee #2, 05 Apr 2024

This study is a comparative analysis of torrential floods that occurred in specific villages on the northern side of Madeira Island during December 2020 and January 2021, compared with earlier local events from 2009, 2012, and 2013. The study focuses on understanding the hydrogeomorphological events characterized by interactions between slope movements (landslides, debris flows) and fluvial dynamics (flash floods) in mountainous regions like Madeira Island, triggered by intense precipitation episodes exceeding critical thresholds, leading to peak discharges in various catchments.

Although the study has some interesting insights, it appears to be in need of a lot of improvements and restructuring to make it of a quality that would be ready to be considered for NHESS. **For example, the description of susceptibility appears to oversimplify the relationships between topography, geology, and flood hazard susceptibility.** English writing should be improved on topics like sentence

constructions, and the flow/narrative of the story should be improved a lot for some sections like introduction and discussion.

Specific comments:

Suggestion to write title without full stop to make it more attractive.

Answer: The new title is as follows: Rainfall analysis in mountain streams affected by torrential floods on Madeira Island, Portugal

Abstract

To increase interpretability and readership of the manuscript please keep to the conventional way of writing an abstract (background, rationale, main message, approach/results, implications). For me now the abstract does not give a proper overview of the manuscript.

Answer:

background, rationale, main message,

Torrential flows are powerful and destructive events that result from a mix of debris and water moving rapidly down steep channels in mountainous areas. They are normally triggered by heavy rainfall. This combination creates a high-density mass that is displaced by gravitational force, often through successive impulses. Predicting torrential flows is crucial because this natural hazard can pose a significant threat to both humans and infrastructure. Critical rainfall analyses is a fundamental research task with practical applications in early warning systems.

approach

Empirical rainfall thresholds are calculated based on historical local-scale torrential flow events and past rainfall measurements that occurred on Madeira Island between 2009 and 2021. This analysis differentiates between rainfall from previous days and weeks and event rainfall. The first parameter uses a calibrated antecedent precipitation technique based on a power law that accounts for the drainage process over time in the catchments. The second corresponds to the maximum 24-hour precipitation, calculated as a sliding sum over the day(s) of heavy rainfall. The results

from the combinations between these two parameters are considered to establish empirical rainfall thresholds related to torrential flows.

<u>results</u>

Our results statistically demonstrate that calibrated antecedent precipitation was significantly different between triggering and non-triggering rainfalls. Therefore, antecedent rainfall influences the occurrence of torrential floods on Madeira Island. By applying this methodology, we were able to determine predefined rainfall thresholds for the occurrence of torrential floods. Calibrated antecedent precipitation over 15 days (110 mm) and 30 days (130 mm), combined with a maximum rainfall of 250 mm in 24 hours, exemplify critical conditions.

<u>implications</u>

As far as we know, this is the first study to introduce predefined rainfall thresholds for the occurrence of torrential floods in Madeira Island catchments. In this context, the rainfall thresholds, particularly the results we have obtained, serve as a crucial input parameter for establishing a robust torrential flood warning system.

Some sentence are very long and hard to dissect.

Refrain from using words like "surprising".

"Early warning system" is mentioned in the abstract, but not in the manuscript. Why is this mentioned only here? And if so, there should be a clear indication why it is included

Answer: The absence of a reference to the early warning system in the manuscript was an oversight, which has now been duly addressed in the new version of the article. The main purpose of critical rainfall calculations stems precisely from the need to have more reliable critical value data for a warning system.

Introduction

Header numbering missing

Answer: Corrected.

Layout of text is different than rest of the manuscript

Answer: Corrected.

What is meant with "Bibliography" line 38?

Answer: this word has been removed in the new version of the manuscript.

Impressive has a positive connotation, so maybe use another word when talking about disasters.

Answer: these reminders have been taken into account in the new version of the article.

Instead of reading an introduction which builds on top a problem statement with background information and scientific relevancy of the identified research gap, this introduction reads as a case study area description. Suggestion to rewrite introduction. The overall objective should be clearly defined based on the research gap. Now it just states it is expected to bring new scientific contributions. The research objectives are not well identified.

What is meant with analyse the data?

Answer: This analysis is based on rainfall data, particularly 10-minute readings from the rain-gauge network.

What type of analysis?

Answer: The identification of critical thresholds was accomplished through a statistical analysis of precipitation data from years with and without torrential flood records. This analysis aimed to detect a clear separation in precipitation behavior between both sample groups.

How is the relevancy demonstrated of the high-resolution susceptibility map?

What is meant with high-resolution?

Is local-scale or small-scale more suitable?

Answer: In the initial version of the article, the cartography served the purpose of providing a schematic representation of areas affected by known torrential floods. The goal was to present the physical boundaries of recent floods in specific localities, including the regions where debris flows occurred. This was achieved through figures

based on a high spatial resolution base map, potentially supplemented by photographic records. However, during the ongoing article revision process, it was decided to exclude this topic from the present study. The reason behind this exclusion lies in the lack of a concrete methodology for assessing susceptibility to torrential floods, including relevant conditioning and triggering factors. And also because the main objective of this study is to determine critical thresholds for heavy rainfall.

Data

To help the reader understand the manuscript better, a flowchart depicting the methodological steps is needed.

Answer: The flowchart has been drawn up and correspond to Fig. 1 in the new version of the article.

The technique is commonly referred to as Annual Maxima

As correctly stated in line 83-83, for impact analysis annual maxima might not be relevant as more than one extreme value per year can be of importance. Why is not a peak over threshold method selected here?

Answer: We chose not to use this method in our analysis because we believe it is more realistic to base our methodology on a sample of rainfall data related to known real cases of heavy rainfall events that have occurred in the mountainous regions of the island and have led to torrential floods.

Please use subheadings for sections throughout the manuscript to help the reader understand the aim of the specific section.

Answer: This suggestion was taken into account during the revision of the text.

Line 91, what is meant by maximum precipitation variable in 24 hours? What is the unit of this variable?

Answer: The maximum rainfall in 24 hours corresponds to the highest amount of rainfall that occurs within the 24-hour moving interval, calculated based on the 10-

minute readings from the udographs on the day(s) of the rain event. The unit of measurement is always in millimetres (mm).

What would be the sensitivity of using k=0.8 to the findings of the study?

Answer: In theory, with the empirical parameter K = 0.9, we assume that 90% of the rainwater that occurred in a certain period prior to the day of interest (even before applying the exponent) remains accumulated in the soils of the catchment-stream system. This evaluation considers rainwater from previous days and weeks, which can contribute to soil saturation, instability, and soil movement. The remaining 10% of that water has already been drained into the water network, percolated, or evaporated.

If the option had been K = 0.8, it would have meant assuming that on steeper slopes (such as narrow-bottomed valleys, as found on Madeira Island), a higher percentage of rainwater (in this case, 20%) quickly runs off the slopes into watercourses or is lost through evaporation or percolation. Since this is an empirical parameter, there is naturally some subjectivity in choosing its right value.

Rainfall

Please also show R2 values for Figure 6

Where there checks done for homoscedasticity of the data?

The plots are difficult to interpret and compare when the x-axis scale changes each subplot in Figure 6

Answer: After submitting the article, all the calculations were revised and an error was detected in the application of the mathematical formula for calibrated antecedent precipitation calculations. Consequently, all the calculations be had to be remade. This process has now been completed, and the arrangement of data pairs in the graphs has been reorganized. With this new arrangement, it no longer makes sense to apply the rules for the equations of the regression lines. Instead, for the different durations shown in Figure 6, new thresholds for maximum precipitation in 24 hours and calibrated antecedent precipitation were identified, using only absolute specific and predefined values of the two variables. These updated values are presented in the corrected version of the article.

The x-axis scale has been standardised.

The rainfall data samples used in this analysis correspond to relatively short climatic series. Therefore, it was decided not to apply the homogeneity tests, normally used for long series of at least 30 years.

Discharge

How does the occurrence of secondary peaks of intense rainfall correlate with the complex flood patterns observed in the studied catchments?

Answer: As a general rule, the occurrence of secondary peaks of intense precipitation contributes to prolonging flood discharges for longer periods (hours), and thus increase the risk of catastrophic floods. In other words, these floods are complex because they result from several intense downpours, which tend to increase the instability of the soil in the upper sectors of the catchments.

How reliable and valid are the peak flood flow estimations obtained from the HEC-HMS model?

Answer: The HEC-HMS (Hydrologic Engineering Center - Hydrologic Modeling System) software was used to estimate flow hydrographs and peak discharges, but without supplemental analysis tools addressing erosion and sediment transport. In this sense, the results obtained have some limitations. In reality, torrential flows are a mixture of water and debris. However, for the purposes of comparative analysis between catchments, we considered that the values obtained reflect an order of magnitude sufficient to perceive the spatial variations of floods. Nevertheless, comparing the values estimated by modeling with those obtained by applying the Manning-Strickler Formula, based on direct measurements in cross sections using channel geometry methods (only available in one of the catchments studied), reveals that the former are underestimated compared to the latter.

Flood risk

Line 436: Susceptibility to?

I find the susceptibility map to be oversimplified as it also seems to be just an indication of previous events. There is limited quantitative analysis or data-driven assessment of susceptibility factors such as slope gradient, geology, rainfall intensity, or land cover. Without quantitative analysis, the susceptibility map may not accurately represent the true spatial distribution and intensity of flood hazards.

The text indicates that the susceptibility map was created based on field survey work and manual identification of areas susceptible to torrential floods, slope movements, and debris flows. The term "cartographic sketch" suggests a less formal and more subjective approach to mapping susceptibility.

Answer: In fact, that was the whole point, to create a less formal and more subjective approach to mapping susceptibility. Let's say that this more simplified approach was intended to provide land-use planners with a source of spatial information on hydrological hazards, based essentially on the historic of occurrences in a given part of the territory, thus making a clear distinction between potential susceptibility and actual susceptibility. However, as part of the in-depth revision of the initial manuscript, at this stage of the research, it was decided to mainly explore the subject of heavy rainfall thresholds, and to remove the analysis of susceptibility to torrential floods from this article.

Indeed Figure 6 is not precisely a map of susceptibility to torrential flooding. Instead, its purpose was to create a schematic figure illustrating the areas affected by the flood that occurred on December 25, 2020. The intention was to demonstrate that in mountainous regions, even in very small catchments (1 km²), floods can pose a significant risk.

Discussion

The discussion appears to be a summation of what was found in the study. There is no discussion on limitations or implications of this study. It would help if this study has a

clearly defined research question to answer, which was also lacking in the introduction.

Answer: The primary objective of this study is to determine critical precipitation threshold values that can lead to torrential flows. To achieve this, we will base our analysis on historical torrential flow events and past rainfall measurements. Specifically, we will compare data from rainfall events that triggered torrential events with data from those that did not. A secondary objective is to obtain complementary hydrological information regarding the relationship between heavy rainfall amounts and flow discharges in small catchments, achieved through a hydrological modelling exercise. The third goal is to discuss aspects related to the uncertainty surrounding the definition of rainfall thresholds and consequent flow discharges. In this context, it is important to consider the uncertainties and limitations of the results obtained, given the limitations of rainfall point measurement methods. Rainfall often occurs in a dispersed manner, which makes it challenging to obtain a sample with meaningful physical representation. Even so, the results obtained are certainly a valuable contribution to improving an early warning system for torrential floods.

List of all relevant changes made in the manuscript.

1 Total revision of the abstract;

2 Total revision of introduction;

3 Partial revision of the methodology;

4 Modification of the structure of the presentation of results and discussion

5 Removal of the topic on susceptibility;

6 Total revision of the conclusion;

7 In-depth research and review of bibliographical references.;